

Specifications for the Optical Parametric Oscillator (OPO) System

The Naval Research Laboratory (NRL) has a requirement for a OPO system composed of a pump laser containing a harmonic generator operating at 355 nm and an optical parametric oscillator/amplifier component. The system must provide direct access to the output beam of the pump laser at wavelengths of 1064 nm, 532 nm and 355 nm, without passing through the OPO component. The system must also allow the operator to switch between the laser fundamental (1064 nm), optimized second harmonic (532 nm) beam, third harmonic beam (355 nm) and fourth harmonic (266 nm) without needing to realign the OPO system when pumped with 355 nm.

1. High energy pulsed Nd:YAG laser with the following specifications:

Pulse repetition rate must be 10 Hz.

Injection seeding of the pump laser is important to the power and beam quality of the OPO.

System must produce a minimum:

1700 mJ at 1064 nm with Injection seeding

850 mJ at 532 nm with Injection seeding

650 mJ at 355 nm with Injection seeding

150 mJ at 266 nm with Injection seeding

System must have Beam Pointing stability of less than ± 25 microradians over an 8-hour period with a temperature variation of ± 3 deg C

Spatial profile must be 70% or better in the near field (1 meter) between the actual beam profile and the least squares fit to Gaussian profile and better than 95% in the far field.

The Q-switched temporal pulse width must meet the following specifications

At 1064 nm; 8-12 ns

At 355 nm; 6-9 ns

The long pulse mode (un-Q-switched) must have a duration of approximately 200 microseconds and exhibit the same beam diameter and divergence as the Q-switched mode. The energy of the long pulse mode must be between 10,000 and 20,000 times less than the peak power of the Q-switched mode.

Energy stability at 1064 nm must be less than $\pm 2\%$ for 99% of the pulses for a one hour period.

The pump laser must utilize a birefringence compensated oscillator for maximized beam quality and energy.

For safety and component longevity reasons, the pump laser must utilize oil/dust-free stainless steel beam tubes between all optical elements. Beam tubes must enclose the entire beam path to add a protective physical barrier against environmental contamination. The beam tubes must be sealed such that they can be purged with dry air or nitrogen for optical surface protection and long component lifetime.

The flash lamp elliptical reflectors used to illuminate the Nd:YAG rod from all sides must be gold plated.

Flashlamp changes will not require the removal of the pump chamber from the laser head. The entire cavity beam path and optics must remain sealed and protected during flashlamp changes. Flashlamps will have color-coded lead wires designating the anode and cathode ends to decrease the chance of installing the flashlamp “backwards” and must exceed 40 million pulses while retaining 90% of IR power.

Laser head must have detachable umbilical from the power supply for ease of transport.

The laser must have a sync pulse generator output to provide a pre- or post-trigger pulse with respect to the Q-switch in the range +500 ns to –700 ns, providing a pre- or post-trigger pulse with a range of 0 to 500 ns with respect to the output pulse.

The laser must be warranted for a period of 2 years on all electrical and mechanical components and 90 days on all optical components. Manufacturer must offer supplemental coverage for all components, including optics, for a period of 2 years. The pump chambers shall be covered under warranty for a period of at least 5 years.

Harmonic Generator

All harmonic generator crystals must be placed in a single housing, which allows harmonic wavelengths to be changed quickly and easily.

The harmonic generator must include both Type I and Type II second harmonic crystals for 532 nm output, a third harmonic generation crystal for 355 nm output and a fourth harmonic generation crystal for 266 nm output. The harmonic generator must also allow access to full energy at 1064 nm output without removing the harmonic generator crystals.

The harmonic generator crystal housing must be temperature controlled using individual heaters for each crystal, and water cooling for the housing, to maximize conversion efficiency and energy stability as appropriate for each crystal.

The harmonic generator must be able to rotate to allow user selected output polarization.

The laser must have mounted dichroic optics to separate 266 nm and 532 nm from 1064 nm (external to Nd:YAG and OPO is acceptable) for external, non-OPO usage.

Dichroic mirrors used to separate different wavelengths must be 38 mm in diameter or larger.

Injection Seeding

The laser must have Injection Seeding for 0.003 cm-1 linewidth at 1064 nm.

Injection seeding laser must use off axis pumping of the gain medium to reduce the risk feedback to the diode. This feedback is the leading cause of diode damage.

Single vendor shall manufacture the YAG laser and injection seeder laser.

2. Optical Parametric Oscillator

The OPO must be a completely solid-state system based on BBO crystals.

The OPO cavity must incorporate an unstable resonator design (Unstable Resonator refers to a patented cavity design, not output stability). This design ensures good beam quality and low divergence, hence the ability to focus to diffraction limited spot sizes. The design also provides the highest frequency conversion efficiency thus eliminating the need for potentially damaging high pump fluence.

The OPO output signal beam divergence must be less than 1 mrad.

The OPO must be continuously tunable from 440-705 and 715-1700 nm without changing any optical components, including dichroic separation optics.

The OPO crystals must be hard-coated to negate the need for temperature stabilization. Hard-coated, sealed crystals must be protected from moisture and environment without heating. Heaters will add destabilizing elements to the OPO platform.

The OPO system must utilize a high energy, robust power oscillator in place of a single pass amplifier. The power oscillator design is less sensitive to the seed beam direction and divergence and requires less seed power compared to single pass amplifier techniques. The reduced pump power density greatly reduces the risk of optical damage.

Energy output at 500 nm must be greater than 75 mJ per pulse, and must be greater than 40 mJ per pulse between 440 nm and 700 nm.

Linewidth must be less than 0.075 cm^{-1} across the entire tuning range.

The OPO system must be fully automated including scanning capability.

The system must have feedback loops that automatically track a small portion of the output of the master oscillator and power oscillator, and optimizes the crystal angles to peak the power (while scanning and while static). This auto-tracking system ensures optimum performance independent of environmental changes (temperature, etc.).

All tuning and scanning controls must be accomplished through a compact one-touch automated remote module and must include an optional RS-232 /IEEE-488 interface capability. The use of a personal computer to control the system must be optional but not required for automated operation.

The remote module must display both signal and idler wavelength readouts and have the capability to pre-program several common automated scan ranges.

LabVIEW drivers for the system must be provided.

The OPO must have the option to install an integral frequency-doubling unit on the same platform as the OPO.

The photodiodes that monitor the output of the master oscillator and power oscillator must provide relative output energies that will be used as a diagnostic.

3. General

The vendor shall provide adequate training for proficient usage of the pump laser and OPO system.

The vendor shall supply a set of manuals and schematics for the pump laser and OPO system and any additional equipment provided by the vendor.

The vendor shall demonstrate that the system meets or exceeds the specifications provided before that system will be accepted and the warranty begins.

Vendor shall demonstrate proficiency in pump laser and OPO system setup and usage by providing a list of similar systems sold recently. The vendor shall also provide evidence of a fully trained service organization.

The system shall be warranted for a period of 2 years on all electrical and mechanical components and 90 days on all optical components. Manufacturer shall offer supplemental coverage for all components, including optics, for a period of 2 years.

4. Optical Table

The dimensions of the optical table must be 5 foot by 10 foot by 8 inch thick and be commercially available. The surface of the table must have a flatness of ± 0.005 inches, must be 3/16 inch thick and must be made from a ferromagnetic stainless steel type 430 with tapped 1/4 by 20 holes drilled on a 1 inch center to center grid spacing and backed with 1 inch deep catch cups below each hole. The optical table core must be composed of a steel honeycomb, closed-cell configuration made with 0.010 inch thick foil and cell size of approximately 0.5 square inches. The shear modulus of the core must meet or exceed 275,000 PSI. The side walls of the table must be damped, formed steel channel with black vinyl cover. The maximum compliance level of the table must be a minimum of 10 micro-inch /lb force input and have a minimum resonant frequency of 110 Hertz and a maximum static deflection of 1.0 micro-inch /lb force. Vibration isolation supports for the optical table will be supplied by NRL.